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ORIGINAL ARTICLE

Evaluation of missing-tooth effect on articular eminence inclination of temporomandibular joint



Meng-Ta Chiang^a, Tsung-I Li^a, Hsiao-Wen Yeh^b, Chi-Chun Su^b,
Kuo-Chou Chiu^a, Ming-Pang Chung^b, Ren-Yeong Huang^c,
Yi-Shing Shieh^{b,c*}

^a Department of Oral Diagnosis & Pathology, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan, ROC

^b Department of Operative Dentistry and Endodontology, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan, ROC

^c Department of Dentistry, Tri-Service General Hospital, National Defense Medical Center, Taipei, Taiwan, ROC

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Abstract *Background/purpose:* Occlusion is an important component of temporomandibular joint (TMJ). Little is known about the association between missing teeth and TMJ changes. The purpose of this study was to determine if a correlation exists between unilateral missing posterior teeth and changes in the inclination of the articular eminence (AE).

Materials and methods: A total of 106 joints in 53 patients (20 men and 33 women) with unilateral posterior edentulism were included. In the same patients, the sagittal outline of the AE and glenoid fossa was traced in panoramic radiographs. The sagittal condylar path inclination was constructed by joining the crest of the glenoid fossa and the crest of AE. This was then related to the constructed Frankfurt's horizontal plane to determine the inclination of AE. The results were subjected to the one-way analysis of variance test. A P value of <0.05 was considered to be statistically significant.

Results: In this study 27% of the individuals were right posterior edentulous and 26% were left posterior edentulous. The mean value of AE inclination was 37.7°, ranging from 4° to 58°. A trend showing increased inclination angle in the nonmissing side compared with the missing side was observed (P > 0.05). The inclination of AE in men was higher than in women on both the missing side and the nonmissing side (P > 0.05). The symmetry equality between the missing and the nonmissing side joint was 1.89%. This value was higher (3%) in the female group

* Corresponding author. Department of Dentistry, School of Dentistry, National Defense Medical Center and Tri-Service General Hospital, Number 325, Section 2, Cheng-Kung Road, Neihsu 114, Taipei, Taiwan, ROC.

E-mail address: ndmcyss@ndmctsgh.edu.tw (Y.-S. Shieh).

than in the male group (0%). Comparing the absolute mean differences, the female group showed a lower difference (9.8°) than the male group (12.11°).

Conclusion: A wide range of values of AE inclination was found regardless of other factors such as side of teeth loss and the sex of patients.

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Introduction

The temporomandibular joint (TMJ) is a complicated articular system located between the mandible and the temporal bone.¹ It enables the mandibular functions via a dynamic balance mechanism and has the ability to move within the three planes of space. The glenoid fossa creates the superior bone part and the mandibular condylar process creates the inferior bone part of the joint.² The articular eminence (AE) is part of the temporal bone on which the condylar process slides during mandibular movements. The inclination of the AE varies across the population and dictates the path of condylar movement as well as the degree of rotation of the disc over the condyle.³ There is no doubt that the TMJ is one of the most complex joints of the body and its structure is further complicated by its close proximity to the dentition, muscles, and other oral structures.⁴ Because of this intimate relationship with the dentition, it is essential for dentists to have a sound understanding of the stomatognathic system.

Previous studies have shown that tooth wear and tooth loss may cause deleterious effects at the TMJ such as resorption of the AE,⁴ and may accelerate the development of degenerative joint disease.⁵ Although there is a wealth of literature on the morphology of TMJ components,^{6–8} little is known about the association between unilateral missing posterior teeth and the osteoarthritic changes in the TMJ, such as flattening of the AE in contemporary populations.

The purpose of this study was to determine if a correlation exists between unilateral missing posterior teeth and changes in the inclination of the AE. If a correlation can be found between easily measured factors such as tooth loss, and the less easily observed changes in the AE, these may be used as predictors of temporomandibular problems.

Materials and methods

Population

This study was conducted in the Oral Diagnosis and Oral Radiology Department of Tri-Service General Hospital, Taiwan, R.O.C. The measurements were performed retrospectively on panoramic records of 106 joints of 53 patients with unilateral posterior tooth loss who had previously visited the clinic. Patient ages ranged from 20 to 85 years. The exclusion criteria were as follows:

1. The presence of congenital craniofacial abnormalities and any systemic diseases which may affect joint morphology such as rheumatoid arthritis.

2. Patients with a fracture or pathologic lesions in the region of the AE, which interferes with performing the measurement on the region.
3. Patients who had reconstruction by prosthetics.

Imaging procedures and measurements (panoramic radiography)

A single operator made all the radiographs in the same radiographic unit (CRANEX EXCEL CEPH, SORDEX, Milwaukee, WI, USA) with exposure factors of 67 kVp and 10 mA. The Pangea Dental (EBM Technologies, Taipei, Taiwan) software program was used for analyses. The images were shown on a 100% scale LCD monitor. Each measurement was repeated twice by two examiners. Ten panoramic radiographs were each traced independently by the observers to coordinate their findings before making interpretations.

The sagittal outlines of the left and right AE and glenoid fossae could be traced on the monitor. The left and right "orbitale" (the lowest point in the margin of the orbit) and the "porion" (the highest point in the margin of the auditory meatus) were identified and the Frankfurt horizontal plane was constructed by joining the two landmarks on each side. The most superior point on the glenoid fossa (the crest of glenoid fossa) and the most inferior point on the AE (the crest of AE) were identified and a second line to represent the mean condylar path inclination (CPI) was constructed by joining the two points. Using these two planes, the AE inclination was measured using the top-roof line method^{3,9} which was the angle between the CPI plane and the Frankfort horizontal plane (Fig. 1).

Statistical analysis

All statistical analysis was performed using SPSS 20 software (Statistical Package for the Social Sciences, IBM Software Group, Armonk, NY, USA) at the level of descriptive statistics, while the differences between arithmetic means were tested for significance using the Student *t* test. The percentage of equality and the mean absolute difference were made to show asymmetry of the measured inclination of the missing and nonmissing side joint on the same image. The one-way analysis of variance (ANOVA) test was used to determine differences in the bilateral, mean, and the difference of AE inclination between sex, age, and side of edentulous group. A *P* value of < 0.05 was considered statistically significant.

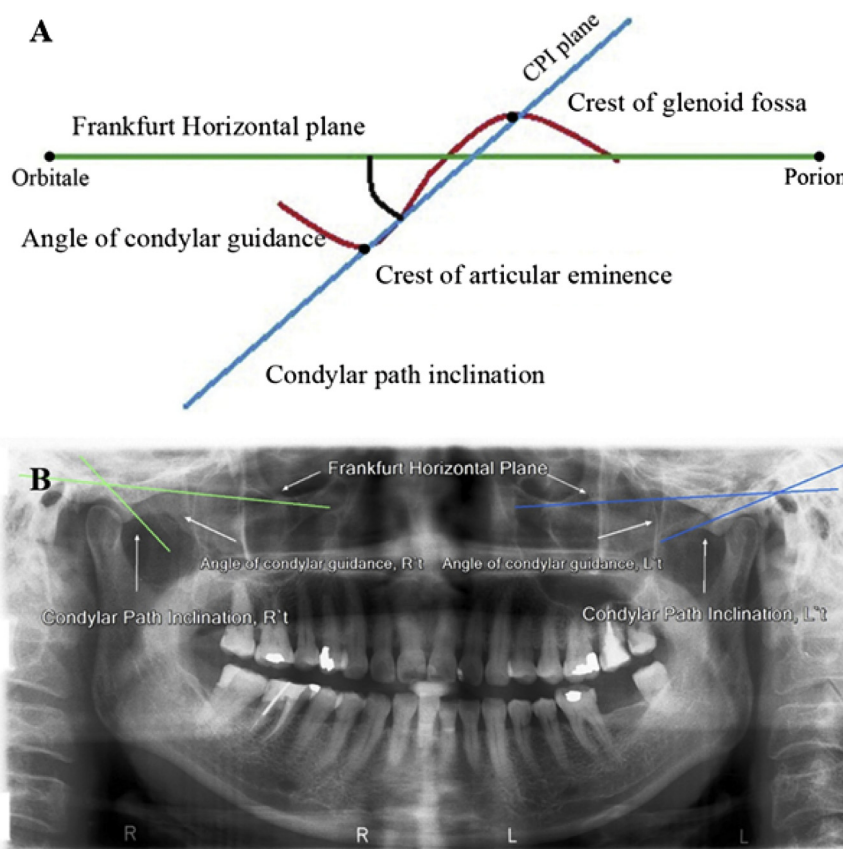


Figure 1 (A) Top-roof line method: line diagram of the panoramic tracing of the angle of sagittal condylar guidance; (B) panoramic radiograph of the patient showing the tracing of the angle of sagittal condylar guidance. (Green line: right sagittal condylar path inclination, blue line: left sagittal condylar path inclination.)

Results

The age and sex of the study population are shown in Table 1. There were 20 men and 33 women included in this study; 27 individuals were right posterior edentulous (RPE) and the rest are left posterior edentulous (LPE). The average age was 52 years and the ages ranged from 23 to 84 years.

The mean measured value for the AE inclination in all measured populations was 37.7° with values ranging from 4° to 58° . The AE inclination of the nonmissing group was slightly steeper than that of the missing one, but this difference was not statistically significant (Table 2, $P > 0.05$).

Table 1 Data for the study group with right and left edentulism.

	No.	Men	Women	Average age	Age range
RPE	27	12	15	51.2	24–78
LPE	26	8	18	53.2	23–84
Total	53	20	33	52.2	23–84

LPE = left posterior edentulism, individuals without four posterior teeth in a left half arch; RPE = right posterior edentulism, individuals without four posterior teeth in a right half arch.

The AE inclination values of the men were higher than those of the women on both the missing side and the nonmissing side; however, these differences were not statistically significant (Table 2, $P > 0.05$).

Examining the symmetry between the missing and the nonmissing side joint of each particular radiograph (Table 3), showed equal values in only 1.89% of the patients and these were all women (3% of the female patients), and the range of values was very wide (-15.0° to $+35.4^\circ$).

When comparing the absolute mean differences (difference obtained by subtraction of the value for the nonmissing side joint from the value for the missing side joint, regardless of sign “+” or “–”, Table 3) the women show a lower difference (9.8°) compared with the men (12.11°).

Table 4 shows that differences in the three variables (age, sex, and side of edentulism) did not reach statistical significance.

Discussion

The AE is a small bone situated anterior to the glenoid fossa and its posterior surface slope varies in the population. Although it is an anatomical structure belonging to the cranium, it is exposed to functional load arising from chewing forces with other structures within the TMJ, and these loads influence its morphological shape.¹⁰ The wide range of inclination values obtained in the study indicates

Table 2 Statistical parameters of the AE inclination in angular degrees.

	Missing side			Nonmissing side		
	Mean \pm SD	Range	CV	Mean \pm SD	Range	CV
Men	36.11 \pm 15.23	4–58	42.3%	41.21 \pm 12.88	14–57	31.3%
Women	34.57 \pm 11.33	13–57	32.8%	39.63 \pm 10.51	17–58	26.5%
Total	35.15 \pm 12.82	4–58	36.5%	40.22 \pm 11.37	14–58	28.3%

CV = coefficient of variation; SD = standard deviation.

Table 3 Average values of the differences between right and left inclination.

Inclination subtracted	Mean difference	Mean absolute difference	% of equality
Men	5.10	12.11	0.00%
Women	5.06	9.80	3.03%
Total	5.08	10.96	1.89%

Mean difference: average values of the differences between right and left inclination, obtained using the formula: non-missing side inclination minus missing side inclination (a negative value means a steeper missing side inclination, and a positive value means a steeper nonmissing side inclination).

Mean absolute difference: average difference obtained by subtraction of the value for the left joint from the value for the right joint, regardless of sign "+" or "-".

that the average values can be used just as orientational information and that it is not advisable to use them in everyday practice.

In the present study, we excluded people aged less than 20 years old because of developmental implications. It has been reported that AE inclination is approximately 45% developed at completion of primary dentition, reaching 70–72% of its adult value around the age of 10 years and 90–94% complete by the age of 20 years.¹¹ In our study population, although the age range is wide (Table 1, 23–84 years), we could not find a significant association between increasing age and changes in AE inclination. In agreement with our results, Jasinevicius et al^{12–14} used dry skulls to study the effect of age on AE and found no association between age and AE. However, advanced aging morphological changes may occur in the AE structure, resulting in differentiation of bone contours and flattening of the AE.^{15,16} Thus, to address the long-term effects of aging on the TMJ and AE inclination, a longitudinal study is necessary.

Although the sex difference in AE inclination does not reach statistical significance, we found AE inclination

values of men were higher than that of women on both the missing side and the nonmissing side (Table 2). A previous study indicated that loss of occlusal support is a causative factor for degenerative changes in the TMJs of female patients.¹⁷ These differences may be mediated in part by morphological differences due to sex hormones which appear during the adolescent period,¹⁸ and also by the amount of functional force affecting the TMJ which varies between male and female individuals.¹⁹ Therefore, the effect of sex on the AE inclination needs to be further investigated using a large cohort study.

Table 2 shows that the value of AE inclination was generally slightly lower on the side of tooth loss regardless of age or sex. This trend did not reach statistical significance and others have reported similar results.³ However, a biomechanical animal study may shed some light on these data: using experimentally induced unilateral tooth loss, Huang et al²⁰ demonstrated that unilateral mastication caused increased loading at the nonfunctional side of the TMJ. Therefore, loss of unilateral posterior support may lead to compensatory remodeling of the missing part of the AE over time. The previous theory of the asymmetry of the AE inclination of the left and right joint, has been confirmed by previous studies^{21,22} where the symmetry equality ranged from 5.1% to 12%, which is slightly higher than our results (Table 3, 1.89%). The difference between the left and the right joint is probably caused by the predominant usage of one side of the dental arches during chewing and consequent unequal distribution of biomechanical forces. Thus, different biomechanical conditions caused by aging and teeth loss may have some effect on remodeling and reshaping of the AE.

The TMJ is difficult to view with conventional techniques because of superimposition of the adjacent dense temporal bone. In particular, panoramic imaging and conventional tomography may yield disappointing results.³ It has been suggested that if panoramic radiography is to be used for the initial radiographic examination of the TMJ, practitioners should be aware of the potential for shape

Table 4 Levels of significance of f-ratios obtained by analysis of variance.

Variable	Level of significance of variable (P value)			
	Missing side angulation	Nonmissing side angulation	Mean angulation	Difference between right and left
Sex	0.822	0.538	0.625	0.769
Age	0.250	0.059	0.150	0.149
Side of edentulism	0.530	0.967	0.669	0.571

Differences significant at P < 0.05.

distortion of the structure.²³ In the present pilot study, in addition to our relatively smaller study population, we cannot exclude inaccuracy due to shape distortion. An appropriate method for accurate measurement of AE inclination such as cone beam computed tomography (CBCT) to measure angles and distances would be used for future studies. Furthermore, due to the limited information on patients' history such as the time since tooth loss, a longitudinal study is necessary to investigate whether the long-term effects of unilateral tooth loss has a different association with the AE inclination.

In conclusion, this was the first study on the effect of unilateral tooth loss on AE inclination and we could not find any significant association in the study group. However, the study found that values for the AE inclination range widely and demonstrate great intersubject variability, regardless of the loss of teeth, side of teeth loss, or sex.

Conflicts of interest

The authors have no conflicts of interest relevant to this article.

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